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TESTING OF A DEMOUNTABLE TIRE
ROADWHEEL CONCEPT



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TESTING OF A DEMOUNTABLE TIRE
ROADWHEEL CONCEPT.

U. S. ARMY TANK-AUTOMOTIVE COMMAND
ARMOR & COMPONENTS DIVISION

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by

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SUMMARY

This was a test of a demountable tire roadwheel concept. The objective was to permit replacing the tire in the field as contrasted with present practice which requires replacing the complete roadwheel. If successful, this would have reduced the logistic burden as it would no longer be necessary to ship failed roadwheels back to the factory to have new tires bonded and molded onto them. There were six wheels plus one extra tire.

Two wheels were subjected to the 48 hour drum test. One failed after three hours and the second failed after 26.1 hours - both by massive blowout. Two wheels were subjected to the six hour drum test. One completed this test without incident but the other failed after 4.6 hours by developing a bulge sufficient to trip the limit switch. A limited vehicle test was conducted with experimental wheels at two positions (four wheels). One failed by massive blowout after 22 miles. It was replaced by the wheel which had developed a bulge on the drum test so that testing could proceed with experimental wheels at two positions. This tire failed by massive blowout after 112 miles. Vehicle testing continued with experimental wheels at only one position (two wheels). After a total of 550 miles of vehicle testing the test was discontinued as conditions prevented the test from being very severe and results to date were adequate to permit evaluation.

CONCLUSIONS

Even after this very limited testing, only three of the seven tires were still intact. The other four had failed by massive blowouts - two during vehicle testing and two during drum testing. It must be concluded that, while the feared problem of tire creep on the wheel had been circumvented, the concept would not be even as satisfactory as current wheels. The failure rate is much too high.

RECOMMENDATIONS

No further testing of this concept is recommended.

ACKNOWLEDGEMENT

Credit for the demountable tire concept and the technical management of the procurement of the samples is due to Earl Ash who is from the Frame and Suspension Program (AMSTA-RKT) as is the author. The author was only responsible for the testing of the samples.

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INTRODUCTION

This project is a test of a demountable tire roadwheel as contrasted with the usual roadwheel which has the solid rubber tire molded and bonded to the metal wheel. It was hoped this concept would prove less expensive than the present type by permitting a new tire to be installed in the field rather than replacing the whole wheel and then shipping the old wheel back to a factory to have a new tire molded onto it.

CONSTRUCTION

The wheel is formed of 3/8" thick aluminum. The rim is sloped at 5° and has an edge raised about 5/8". There is a matching flange which permits the tire to be assembled and clamped. There is a steel ring embedded in the rubber tire. While the flange is being tightened to the wheel, the excess of rubber between the wheel and the ring is compressed and forced to flow around the edge of the ring. This causes the tire to bulge upward at the edges as shown in Figure 1 and in Figure 2. The components are shown in Figure 3. The assembled wheel is shown in Figure 4, and in figure 5.

TESTS AND RESULTS

Each of the six experimental wheels with demountable tire was identified by a number (1 through 6). Each wheel was marked so as to permit inspection of the tire for creep on the wheel.

<u>WHEEL NUMBER</u>	<u>WEIGHT (POUNDS)</u>	<u>DUROMETER HARDNESS (SHORE A)</u>
1	59.4	58-61
2	60.0	58-61
3	59.5	60-63
4	59.7	59-63
5	59.7	59-63
6	59.6	60-62
Spare Tire	18.25	64-67

Note that the weight of this wheel is approximately 25 pounds more than the 35 pound weight of the standard M113 roadwheel. Also the durometer specification for the standard M113 wheel is 70+5 making the rubber on these test wheels somewhat softer. It should be noted that the standard specification for roadwheels in MIL-T-3100B is 70+10. A load-deflection curve is shown in Figure 6.

DRUM TEST - 6 HOURS

Wheels numbered 1 and 2 were each mounted on a hub and spindle and checked for radial runout. Then each wheel was loaded radially against the drum and run at 30 mph for two hours at 925 pounds, for two hours at 1015 pounds, and for two hours at 1110 pounds.

Wheel number 1 failed after 4.6 hours. A bulge developed on the tread large enough to trip the limit switch. The bulge diminished somewhat after cooling down. It was not cut open to verify the separation as we wanted to use it as a possible spare for the vehicle tests due to the very limited number of samples. The ambient temperature was 96°F to 102°F. The tread temperature at the time of failure was not recorded. The radial runout was .018 inches T.I.R. No creep of tire was observed.

Wheel number 2 completed the six hour test successfully. The ambient temperature varied from 96°F to 102°F and the tread temperature was 120°F at the end of the six hours. Radial runout on this wheel was .042 in.T.I.R. No creep of the tire on the wheel was noted.

DRUM TEST - 48 HOURS

Wheels numbered 3 and 4 were each mounted on a hub and spindle and checked for radial runout. Wheel number 3 had a T.I.R. of .054 inches. Wheel number 4 had a T.I.R. of .031 inches. The wheels were then loaded radially against the drum at 2095 pounds and run at 10 mph. The ambient temperature was 90°F.

Wheel number 3 failed by blowout after 26.1 hours. The tread temperature was 120°F. The blowout consisted of a length of 23.5 inches around the circumference and approximately .75 inches wide as measured from the edge of the tire inward. There was then a length of 6.5 inches circumferentially that was intact followed by another 31.0 inches length of blowout as much as 1.375 inches wide. The blowout covered about two thirds of the circumference. The tire was stripped from the steel insert for inspection and is shown in Figure 7. No creep was noticed between the tire and wheel.

Wheel number 4 failed by blowout after 3.0 hours. The tread temperature was not recorded. The blowout area extended circumferentially around the entire wheel. The width varied from half an inch to the entire 1.75 inch width of the steel ring. Figure 8 shows wheel number 4. No creep of the tire on the wheel was observed.

It was found that wheel number 3 had lost 0.15 pounds during testing and wheel number 4 had lost 0.20 pounds. Wheel number 1 had not lost any weight. The loss of weight is undoubtedly due to rubber decomposed and vaporized.

VEHICLE TEST

Wheels numbered 5 and 6 were installed at the number one right position at the front of the vehicle. The spare tire was used to replace the damaged tire on the number 1 wheel and mounted at the number four right inside position with the undamaged (but drum tested) wheel number 2 mounted on the number four right outside position. It should be pointed out that the number one right position receives about average abuse whereas the number four right position is punished a little more severely as indicated by a previous test. (See TACOM Technical Report Number 12080 - pages 24 and 25.) These wheels were to have been vehicle tested during that previous test at GM Milford Proving Ground but the wheels were not delivered on time. Therefore, the vehicle test was conducted at USATACOM and was restricted to some running on the paved test track at up to 30 mph and some on the dirt track at up to 20 mph at Building 219. Number four right inside wheel suffered a blowout after 22 miles at 20 mph on the dirt track. This was the extra tire supplied by the manufacturer and it had not been run on the drum testing. Tire number 1 that had developed a bulge on the drum test was reassembled on wheel number 4 and put on the vehicle at the number four inside right position. After another 83 miles on the paved track and 29 miles on the dirt track tire number 1 failed by blowout. Separation had no doubt begun during drum testing but had not yet developed to the point of a blowout. Standard wheels were mounted at the number four right position so testing could continue. Wheel number 2 was kept for a spare. After 59 miles on the paved track the vehicle was barred from using it due to worn track pads damaging the track. Testing shifted to the dirt track but had to be stopped because of dust conditions and the proximity of buildings. To permit testing to continue the dirt track was watered each day. Testing continued for nine days this way but was then discontinued as unsatisfactory. It was felt wetting the track prevented any heat buildup in the tire, speed could not exceed 20 mph, and there was no rough terrain as we would have on cross-country. Wheels numbers 5 and 6 on the right front had accumulated 550 miles.

ANALYSIS OF RESULTS

The drum testing procedures are specified in MIL-T-3100B. Experience indicates that tires which pass the 48 hour drum test successfully, also perform successfully in the field. Both of the samples subjected to the 48 hour drum test failed by massive blowouts - one after three hours, and the other after 26.1 hours. Of the two samples subjected to the six hour drum test, one failed after 4.6 hours and the other completed the six hours without incident. The failures consisted of failure of the bond between the rubber and the steel ring insert in the tire. This apparently occurred because of heat buildup in the rubber and then progressed to the point of massive blowout of the rubber.

On the vehicle testing two tires failed by massive blowout. Both of these tires were at the number four right inside position. The first failed after just 22 miles at 20 mph on the dirt test track. The second failed after 112 miles about 1/3 of which was on the dirt track and 2/3 on the paved track. It should be noted that the second tire had developed a bulge in the drum testing before being put on the vehicle. Testing was terminated after 550 miles. It was felt that conditions prevented adequate testing. First, only one wheel position was equipped with the wheels to be tested while all other positions were equipped with standard wheels. Second, the experimental wheels were considerably softer than standard wheels and for that reason were probably not carrying a normal share of the load. Third, the test track had to be kept wet because of dust conditions and the wetness prevented heat buildup on the tires. Fourth, the small track restricted speed to 20 mph maximum. Fifth, the results of the earlier part of the test, before conditions became so restrictive, were considered adequate to judge this concept.

The rules for vehicle testing in MIL-T-3100B say that tires must last for 2250 miles or in the case of failures the average mileage of five tires (which must include all failed tires) shall be 2250 miles with the test not exceeding 3000 miles. If it be assumed that three tires lasted 3000 miles each the average mileage of our sample would be as follows:

$$\frac{9134}{5} = 1827 \text{ miles (maximum average possible)}$$

The relatively soft rubber used on these tires may have been dictated by the need to displace a considerable volume of rubber from between the wheel sloped surface and the steel ring but the soft rubber by permitting more deflection develops more heat which is a primary cause of failure. The bond failure has been transferred from a bond at the wheel to the bond at the ring and it would seem from this limited test that failures would be more frequent and tire life shorter.

Another contributing factor to this failure rate is the 70% increase in wheel weight which increases the dynamic inertia loads on the tire as the wheel is forced upward by a hump in the terrain since $F = ma$. This limited test did not lead to the track center guide getting over into the rubber tire but when this does happen (and it happens frequently in the field) there is a greater chance of serious damage as the center guide will be tending to pull the flange and wear plate from the wheel as it tries to pull back into proper position. It should be noted that no creep of the tire on the wheel was noted. It had been expected that this would be a problem. But in overcoming this potential problem a considerable amount of rubber was displaced through some distance and it is possible the strain contributed to the bond failure at the steel ring. The disadvantages seem to outweigh any possible advantage of this concept. No further testing of this concept is recommended.

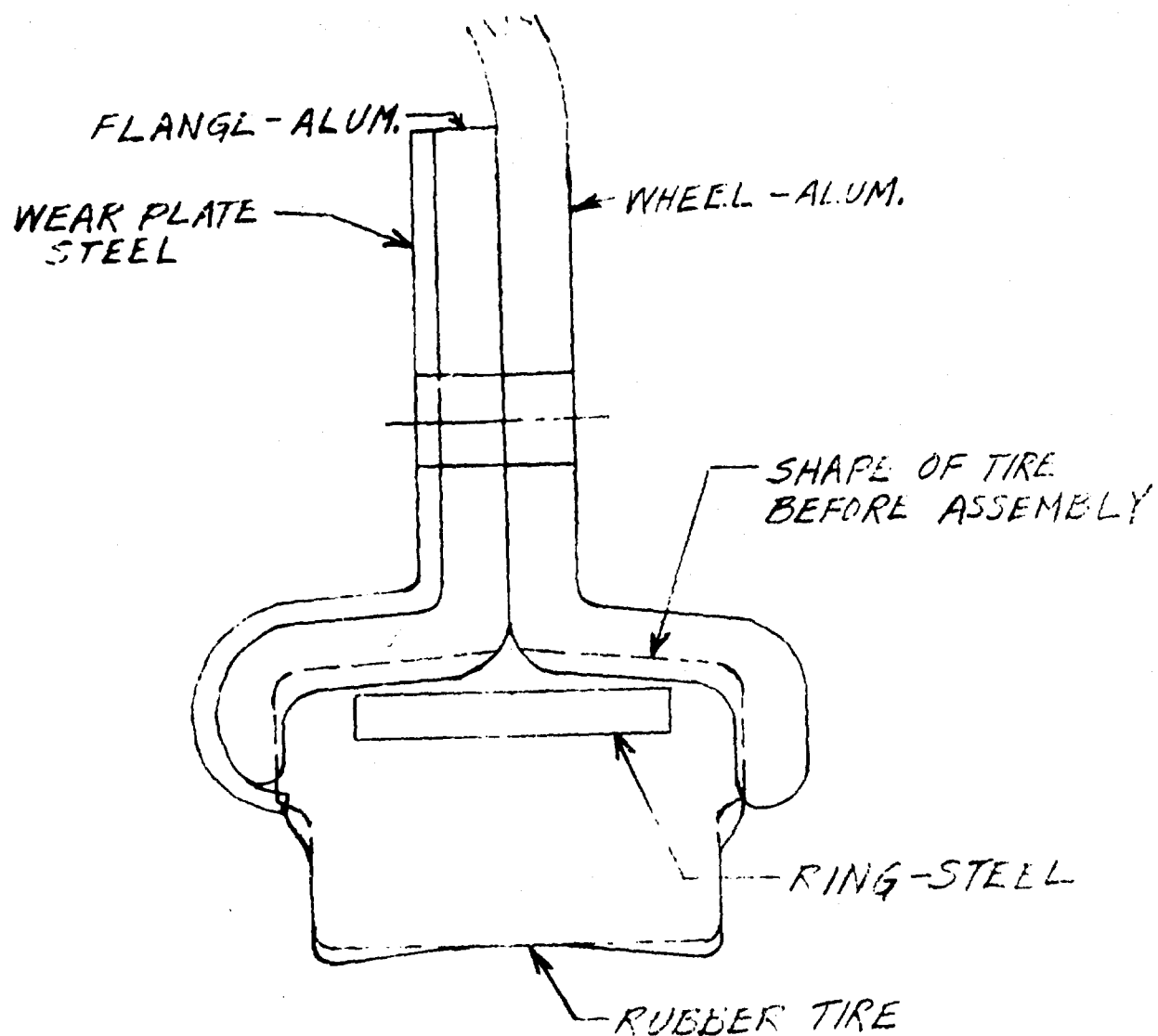


FIG. 1

CONSTRUCTION OF WHEEL. NOTE HOW RUBBER IS SQUEEZED FROM BETWEEN WHEEL AND RING DURING CLAMPING. OUTER EDGES OF TIRE ARE RAISED AS RESULT.





FIGURE 2 - Assembled wheel on the left and unassembled tire on the right.
Note the raised edges of the tire on the assembled wheel.



FIGURE 3 - Wheel components from top to bottom - wheel, tire, flange, and wear plate.

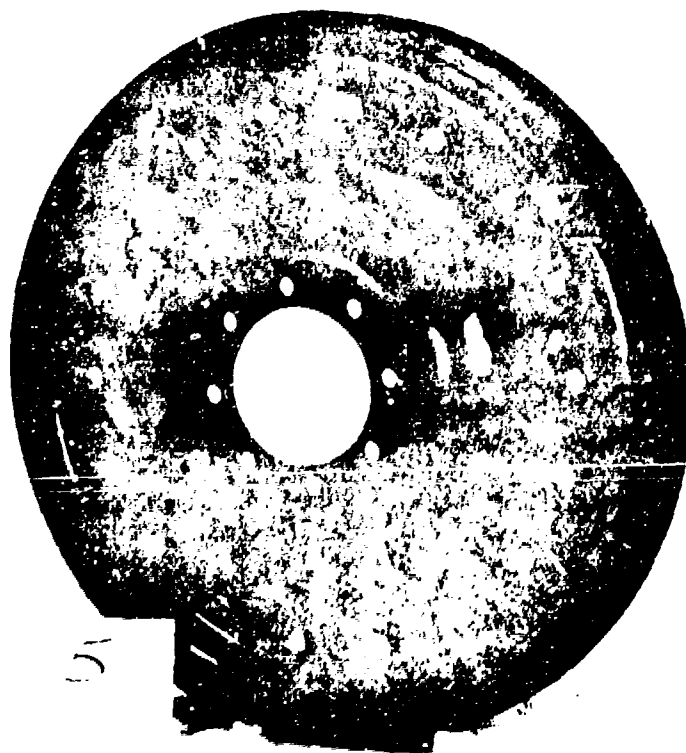


FIGURE 4 - Assembled wheel from Wear Plate side.

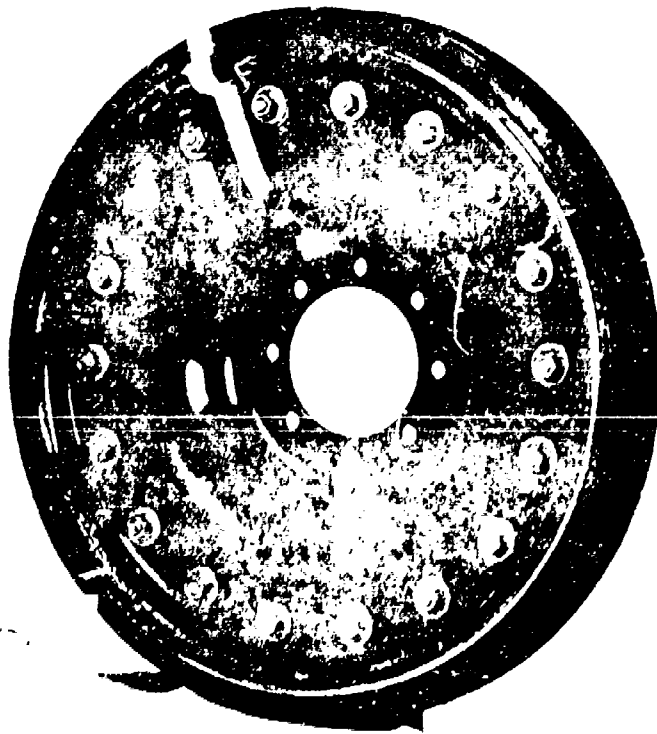
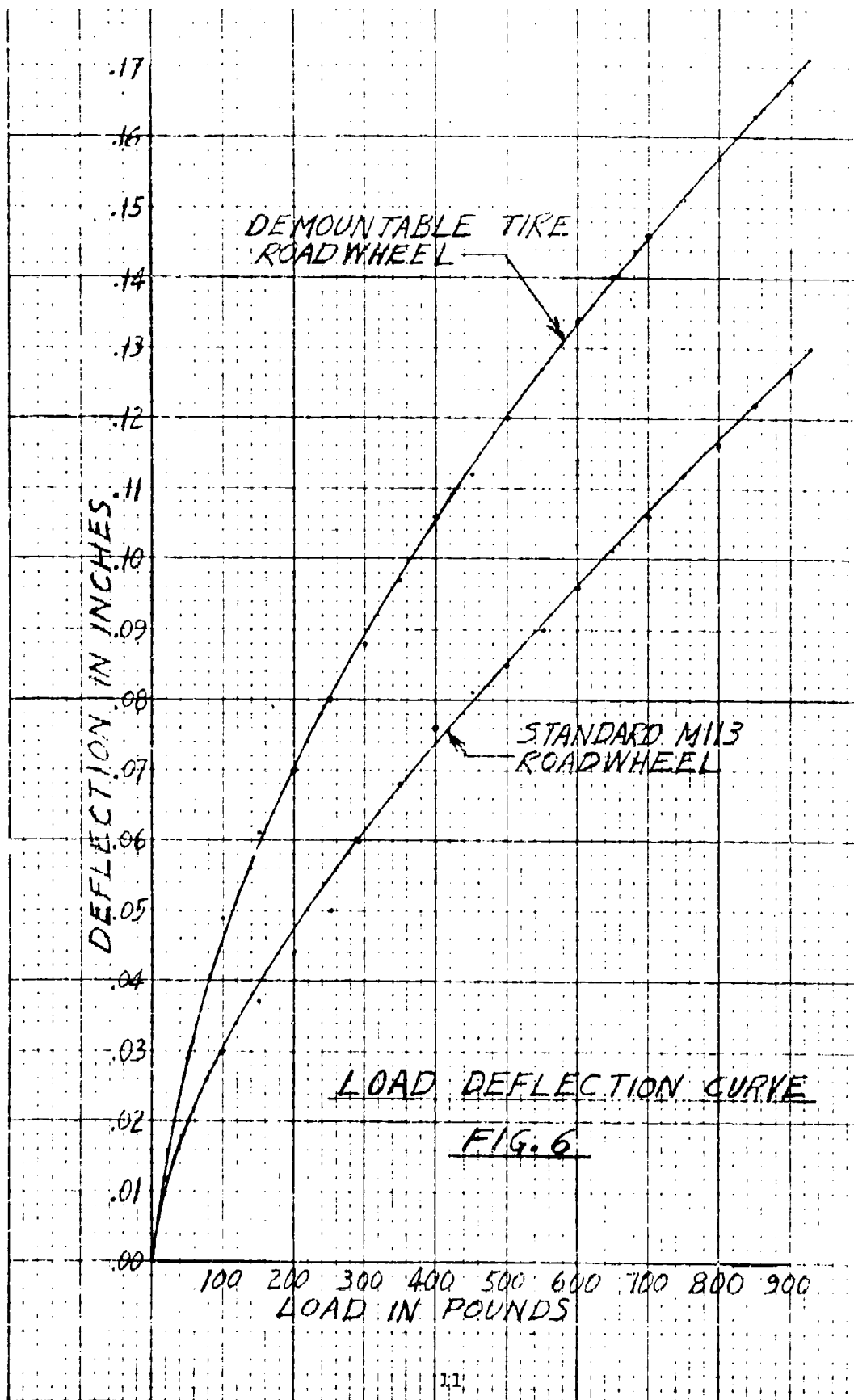


FIGURE 5 - Assembled wheel from Wheel Disc side.



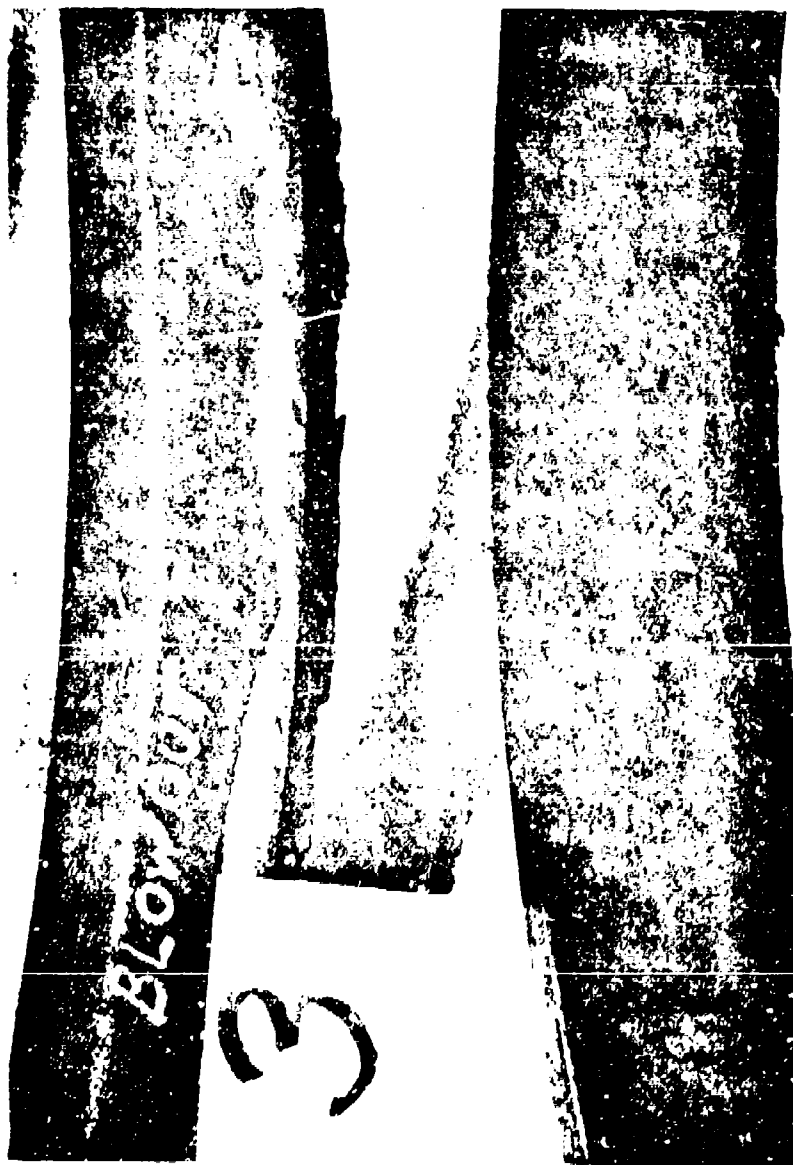


FIGURE 7 - Wheel Number 3 after tire (below) was stripped from steel ring insert (above).
The bright area shows where separation had occurred.

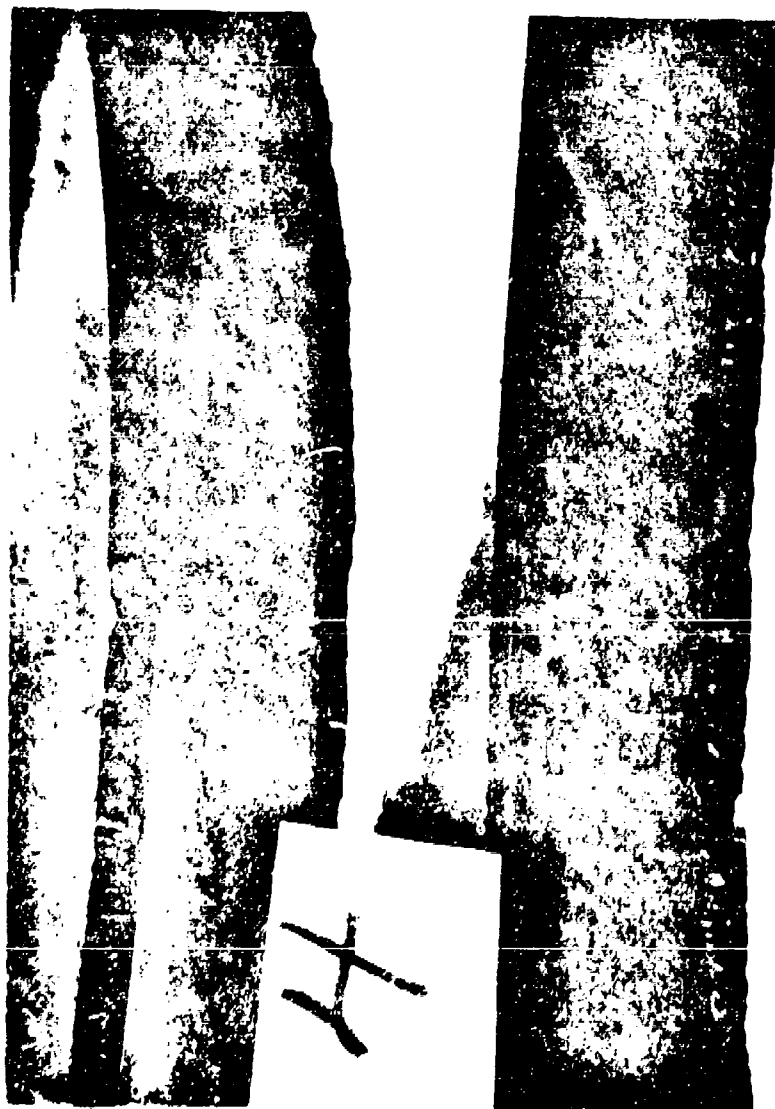


FIGURE 8 - Wheel Number 4 showing the steel ring (above) and the blowout tire (below) after drum test and separation of tire from ring. The bright area on the ring indicates area which had separated and rubber had rubbed for a while before final failure.

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